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Do Tax Policies Stimulate Investment in Physical and Research and Development Capital?

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and
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Among tax policies designed to stimulate investments in Pakistan, the investment tax credit has not been cost-effective. But allowing full expensing for research and development costs has been.

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This paper — a product of the Public Economics Division, Country Economics Department — is part of a larger effort in PRE to evaluate tax incentives for industrial and technological development. Copies are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Ann Bhalla, room N10-053, extension 37699 (25 pages, with tables).

Tax policy instruments are often used to stimulate private investment in developing countries. But researchers have not explored how well such policies have met stated policy objectives.

To evaluate the cost-effectiveness of tax incentives for industrial and technological development, Shah and Baffes specify a dynamic production structure model with endogenous capacity utilization.

Taxes and incentives are part of the user cost of capital, and thereby affect producer decisions about choice of inputs, technology, and capital accumulation.

Empirical estimates of this model allow one to infer both the impact of investment incentives and their implications for revenues foregone by the government.

The model results yield an objective, empirically derived cost-benefit ratio that is superior to standard cost-benefit analysis and King-Fullerton type marginal effective tax rate analysis.

Shah and Baffes apply this model empirically for Pakistan. The results suggest that the investment tax credit has not been effective at stimulating investments in Pakistan. The private investment stimulated has been less than the government revenues foregone.

Allowing full expensing for research and development expenditures, on the other hand, has been cost-effective.

Table of Contents

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I. Introduction

Tax policy instruments are frequently used to stimulate private investments in developing countries. The impact of such policies in meeting stated policy objectives remains an unexplored area of research. This paper specifies an empirical framework to evalute the cost effectiveness of incentives for industrial and technological development offered through the tax code. It takes a first step in quantifying the impact of investment incentives in stimulating additional investment and also draws implications of such measures for government revenues. Its major point of departure from previous studies on this subject for developing countries is that it models a dynamic production structure with endogenous capacity utilization. Taxes and incentives enter into the user cost of capital and thereby affect producer decisions as to the choice of inputs, technology and capital accumulation. Empirical estimation of this model allows one to infer the impact of investment incentives as well as revenue foregone implications of such tax expenditures. Thus the model results yield an empirically derived cost-benefit ratio which due to its objective nature is superior to standard cost-benefit analysis and King-Fullerton type marginal effective tax rate analysis (for developed country applications see Shah (1986) and Bernstein (1987)).

Pakistan has been chosen as a case study for an empirical examination of the effectiveness of investment incentives in view of the policy emphasis on these instruments and also because of excellent time series and cross section industry level data. Section II describes in brief the regime of tax incentives for industrial and technological development in Pakistan. Section III describes the theoretical model as well as presents an empirical specification. Section IV describes the data and estimation and testing procedures. Section V presents empirical results. Finally, Section VI carries out policy simulations and draws overall policy implications from the analyses presented in this paper.

The paper concludes that the investment tax credit has not been an effective instrument for stimulation of investment in Pakistan and that the private investment stimulation offered by this measure, falls short of the revenues foregone by the government. Full expensing allowed for R&D expenditures, on the other hand, has been found to be a cost-effective instrument of tax policy.

II. Corporate Tax Incentives in Pakistan

Pakistan has followed a stable corporate tax rate regime since early 1960s. Corporate income tax rate at 30% and a super tax at 25% have been maintained consistently during the last two decades. Only in the fiscal year 1989-90, was the super tax rate brought down to 15%. Foreign direct investment receives tax treatment equivalent to domestic investment. Losses are allowed to be carried forward six years but no carryback of such losses is permitted. A sales tax at 12.5% is payable on all domestically manufactured goods by the producer and on imported goods by the importer. Currently (1989-90), import duties at differential rates are imposed on imported machinery and equipment. These rates vary from 20% to 50% if similar machinery was not manufactured in Pakistan and a higher rate of 80% applies to imported machinery with domestic substitutes. Businesses are further subject to a large number of miscellaneous licensing fees and charges.

The regime of fiscal incentives through the corporate income tax has experienced significant changes over time. From time to time, Pakistan has relied upon a variety of fiscal incentives to stimulate investment. These include accelerated capital consumption allowances for certain physical assets, full expensing for R&D investments, tax rebates, regional and industry specific tax holidays and investment tax credits. These are briefly discussed below:

Tax Holidays: Tax holiday for two years for specific industries (e.g., engineering goods) and specific regions (most of the country except major metropolitan areas) was introduced in 1959-60. The holiday period was subsequently raised to four years in 1960-61. These tax holidays were eliminated in 1972-73 but reinstated again in 1974-75. Presently tax holidays for five years are permitted to engineering goods, poultry farming and processing, dairy farming, cattle or sheep breeding, fish farming, dates processing and manufacture of agricultural machinery industries and also to all industries in designated areas of the country.

Investment tax credits: Industries are eligible for varying tax credits according to location. A general tax credit for balancing, modernization, and replacement of plant and equipment was introduced at 15% rate in 1975-76 but its application was restricted to designated areas. Since 1976-77, the credit was made available regardless of location and type of industry. This credit was withdrawn in 1989-90 and reinstated again in 1990-91.

Tax rebates: Companies exporting goods manufactured in Pakistan are entitled to a rebate of 55% of taxes attributable to such sales.

Accelerated Capital Consumption Allowances: Capital consumption allowances follow accelerated schedules for machinery and equipment, transport vehicles and housing for workers (25%), oil exploration equipment (100%), ship building (20-30%), and structures (10%) on a declining balance method. Expenditures relating to research and development, transfer and adaptation of technologies and royalties are eligible for full expensing.

Of the incentives enumerated earlier, only the two general incentives, namely, investment tax credit for physical investment and full expensing of R&D expenditures are the subjects of investigation in this paper. Since these two types of incentives are widely used in both the developed and the developing worlds, an evaluation of their impacts are expected to yield lessons of general interest to policy makers in Pakistan and elsewhere. The following sections present an empirical examination of this issue.

III. The Model

A flexible accelerator type dynamic factor demand model with endogenous capacity utilization (see Epstein and Denny, 1983), as described in the following section, is eminently suitable to examine the impact of tax policies on investment in a developing economy. The model employs a flexible and non-restrictive technology and captures short run divergence of fixed factors from their equilibrium values as well as the speed of such adjustments.[1] The theoretical underpinnings and empirical form of this model is discussed in the following:

i. A Flexible Accelerator Model

Consider that a typical firm in manufacturing industry faces the following short-run cost function (C (·)):

$$(1) \quad C(K,I,W,Y) = \min_{Z} \left(W'Z:\ Y = F(Z,K,I)\right)$$

where Z denotes the vector of perfectly adjustable factors, K denotes the vector of quasi-fixed stocks, I denotes gross investment in those stocks, Y is the level of output while W is the price vector associated with the perfectly adjustable inputs. $F(Z,K,I)$ describes the technology and satisfies all classical properties: twice continuously differentiable, increasing in (Z, K) and decreasing in I. The fact that it is decreasing in I reflects the assumption that the quasi-fixed factors are subject to increasing internal costs of adjustment (see Treadway (1970, 1974) and Mortensen (1973)). $C(K,I,W,Y)$ is the instantaneous cost function which satisfies: $C \geq 0$; C is increasing in (Y, I) and decreasing in K; C is convex in I and concave in W.

At any point in time the firm takes input prices, output, and state of technology as given and minimizes the discounted sum of future costs over an infinite horizon. Specifically, the firm selects the investment path that solves:

$$(2) \quad V(K,Y,P) = \underset{\{I\}_{t=o}^{\infty}}{\text{Minimum}} \left[\int_o^{\infty} e^{-rt} \left(C(K,I,W,Y) + P'K\right)dt:\ \dot{K} = I - \delta K;\ K\big|_{t=o} = K_o\right]$$

where δ is a diagonal matrix composed of the depreciation rates; δ_i is the depreciation rate of the i^{th} stock; P is the user cost (rental rate) vector corresponding to K; r is the real rate of discount, which is assumed to be constant. We assume static expectations with respect to output and prices, i.e., the current level of output and prices will prevail forever. The remaining notations are as follows: (′) denotes transposition: ($^{-1}$) denotes inversion; a dot over a function (e.g. $\dot{K}$) denotes differentiation with respect to time. Boldface-type letters represent vectors or matrices. Finally, subscripts of functions denote differentiation (e.g. V_p denotes differentiation of V with respect to the vector P.

Note that the user cost of capital embodies the provisions in the tax codes and is defined as follows (see Auerbach, 1990):

$$P = q\,(r + \delta)(1 - \gamma - \tau z)((1-\tau)\Theta)^{-1}$$

where q = purchase price of capital

r = weighted average real cost of debt and equity finance

δ = economic depreciation rate

γ = investment tax credit rate

τ = corporate tax rate

z = present value of depreciation allowances

Θ = a profitability parameter.

V(K, Y,P) is the value function and is characterized by the following set of properties (for notational convenience we suppress its arguments):[2]

$$V \geq 0;\ V \text{ is concave in } P;\ (r+\delta)V'_k - P - V_{kk}\dot{K}^* < 0;\ V'_k < 0;\ rV_y - V_{yk}\dot{K}^* > 0.$$

After defining the value function we can apply the following analogue of Shephard's lemma (McLaren and Cooper, 1980):

$$\text{(3a)} \quad \dot{K}^*(K,Y,P) = V_{pk}^{-1}\,(rV'_p - K),$$

$$\text{(3b)} \quad X^*(K,Y,P) = -rV'_w + V_{wk}\dot{K}^*.$$

Expressions (3a-3b) define the policy functions or the optimal stock profiles for both quasi-fixed (3a) and perfectly adjustable (3b) factors. Upon application of a specific functional form, (3a-3b) will yield the set of dynamic input demands.

ii. Empirical Model

In order to empirically implement the model we have to approximate (2) by a functional form. We specify the following quadratic value function (Epstein and Denny, 1983):

$$(4)\quad V(K,y,P) = (1/2)\begin{bmatrix} P' & W' \end{bmatrix}\begin{bmatrix} B_{pp} & B_{pw} \\ B'_{pw} & B_{ww} \end{bmatrix}\begin{bmatrix} P \\ W \end{bmatrix} Y + \begin{bmatrix} P' & W' \end{bmatrix}\begin{bmatrix} A_{pk}^{-1} \\ A_{wk} \end{bmatrix} K + \begin{bmatrix} P' & W' \end{bmatrix}\begin{bmatrix} r^{-1} A_{pk}^{-1} & 0 \\ 0 & r^{-1} \end{bmatrix}\begin{bmatrix} H_p \\ F_p \end{bmatrix}.$$

B_{pp}, A_{pk}, A_{wk}, B_{ww}, B_{pw}, H_p, and F_p denote appropriately dimensional matrix parameters; $B'_{pp} = B_{pp}$, $B'_{ww} = B_{ww}$, and $B'_{pw} = B_{pw}$. Applying Shephard's lemma analogue (3a) to the value function (4) results in:

$$(5a)\quad \dot{K}^{*}(K,Y,P) = (r - A_{pk})K + rA_{pk}(B_{pp}P + B_{pw}W)Y + H_p.$$

$\dot{K}^{*} = \dot{K}^{*}(K_o,Y,P)$ denotes the levels of net investment, i.e., the dynamic factor demands. Further, applying (3b) to (4) will yield the demands for the perfectly adjustable inputs:

$$(5b)\quad Z^{*}(K,Y,P) = -r(B_{ww}W + B_{pw}P)Y - rA_{wk}(K - r^{-1}\dot{K}^{*}) - F_p.$$

Equations (5a) and (5b) form the basis for estimation. Appendix A offers a detailed description of the steps involved to arrive at (5a) and (5b).

Notice that an application of Euler equation to (2) will yield the flexible accelerator adjustment paths for K.

$$(6)\quad \dot{K} = M(r)(K - \bar{K}(Y,P)),$$

where $M(r)$ is the matrix describing the adjustment mechanism and $\bar{K}(Y,P)$ denotes the steady state levels of capital stocks. Then, we can express the set of input demands defined in (5a) in terms of (3) if we set:

$$(7a)\quad M(r) = r - A_{pk}, \text{ and}$$

$$(7b)\quad \bar{K}(Y,P) = -(r - A_{pk})^{-1}(rA_{pk}(B_{pp}P + B_{pw}W)Y + H_p),$$

where (7a-7b) express (5a) in the flexible accelerator form.

IV. Data, Estimation, and Testing Procedure

Data in the current study cover the 1956-1985 time period for total private sector manufacturing industries in Pakistan and were obtained from various Pakistan government publications. A total of five inputs were included in the study: three quasi-fixed (land and buildings, machinery and equpiment, and R&D) and two perfectly adjustable (labor and intermediate inputs). Basic data on input shares and their growth rates are presented in Table 1. A detailed description of the data as well as the derivation of the rental rates of capital used in the analysis is offered in Appendix B.

Since the model of the previous section was developed in a continuous time framework, some modifications had to be made to render it estimable. First, $\dot{K}$ was replaced by the discrete approximation $(K_t - K_{t-1})$ and the system of equations (5a-5b) was modified accordingly. Second, the time trend, which a measure of output augmenting technical change, enters the equations as a discrete approximation of the exponential function $e^{-\beta t}$. Finally, a disturbance error term is additively appended to each equation. These disturbance terms reflect random errors in optimization and are assumed to possess classical statistical properties. While the introduction of such an error structure is an ad hoc procedure, it shares the merit of keeping estimation straightforward, while focusing on economic characteristics of the model.

Since (5a) is a closed form solution for endogenous variables, seemingly unrelated regressions (SUR) were used to estimate the model. In particular the nonlinear ITSUR procedure available in SAS was utilized to simultaneously estimate the parameters of each equation.[3] Because the covariance matrix was iterated to convergence, the estimated parameters are asymptotically equivalent to full informatin likelihood estimates (under the assumptions of the error and model structure).

Price elasticities are calculated as $\varepsilon_{ij} = (\partial K_i/\partial P_j)(P_j/K_i)$, where P_j refers to the rental rate of input j. Those expressions pertain to short-run elasticities. To obtain the long-run elasticities we estimate the steady state level of stocks, K^*. This results in the substitution of the matrix A_{pk}

Table 1: Average Growth Rates of Inputs and Input Shares in the Pakistani Manufacturing Industry.

Period	K_1	K_2	K_3	K_4	K_5
Average Annual Growth Rates of Inputs (in percentages)					
1956-65	12.7	11.2	11.5	6.2	8.4
1966-75	.1	3.6	4.2	4.2	8.0
1976-85	3.2	1.2	15.8	-0.2	13.4
Average Input Shares in Total Cost (in percentages)					
1956-65	14.39	32.59	0.38	39.26	13.37
1966-75	13.67	38.02	0.41	35.13	12.78
1976-85	8.49	34.24	0.50	38.71	18.07

SOURCE: Calculated from data described in Appendix B.

NOTES: K_1 = land and buildings; K_2 = machinery and equipment; K_3 = R&D; K_4 = labor; K_5 = intermediate inputs.

by the matrix $(A_{pk} - r)^{-1} A_{pk}$ in (6). Long-run elasticities are then derived in a straightforward fashion. Output as well as tax elasticities are obtained in a similar manner.

V. Empirical Results

Tables 2 and 3 report parameter estimates regarding the quasi-fixed and perfectly adjustable factors.[4] Of these, adjustment coefficients are of special interest. These coefficients give the speed of adjustment of the capital inputs to their respective long-run equilibrium levels. Specifically: the land and buildings coefficient (M_{11}) is -0.18 which indicates that about 18% of the adjustment process takes place within a year or alternatively it takes more than five years for the full adjustment to occur. On the contrary, the coefficient associated with machinery and equipment (M_{22}) indicates that the full adjustment will occur in slightly less than two years. Finally, the R&D adjustment coefficient (M_{33}) indicates that 26% of the adjustment process will occur within a year. The relatively slow adjustment of R&D as opposed to machinery and equipment is consistent with studies for Canada (Bernstein, 1986) and the US and Japan (Nadiri and Prucha, 1989). Another result of interest is the cross-adjustment coefficients of land and buildings and machinery and equipment with R&D. Contrary to the above mentioned studies, here we find that a deficient stock of R&D induces substantial decrease in physical capital.

Table 4 reports short- and long-run price and output elasticities. The short-run response of capital use to own rental rate changes is very small and negative as expected. Long-run responses on the other hand are substantially larger and exceed unity for structures. Increases in output have a positive long-run effect on all inputs with the elasticity exceeding unity for physical assets and R&D capital.

Table 5 reports the corporate tax rate and investment tax credit elasticities. As expected, corporate income tax rate increases adversely affect

Table 2: Reduced Form Parameter Estimates -- Quasi-Fixed Factors.

Parameter	Estimate	Parameter	Estimate
M_{11}	-0.1897 (0.77)	E_{23}	1.6952 (0.53)
M_{12}	-0.0476 (0.44)	E_{31}	-0.0003 (0.08)
M_{13}	10.2074 (0.70)	E_{32}	-0.0028 (0.47)
M_{21}	-0.1012 (0.23)	E_{33}	-0.0050 (0.67)
M_{22}	-0.5562 (2.74)	G_{11}	-0.2756 (0.87)
M_{23}	60.1381 (2.29)	G_{12}	0.3451 (0.87)
M_{31}	0.0059 (2.37)	G_{21}	-1.4481 (2.42)
M_{32}	-0.0003 (0.29)	G_{22}	1.3963 (1.95)
M_{33}	-0.2634 (1.77)	G_{31}	0.0062 (1.76)
E_{11}	-0.0900 (0.24)	G_{32}	-0.0011 (0.28)
E_{12}	-0.1414 (0.24)	β	0.0379 (2.30)
E_{13}	0.1993 (0.27)	H_1	-40.5454 (1.01)
E_{21}	0.5306 (0.79)	H_2	-219.2600 (2.71)
E_{22}	-0.8115 (0.77)	H_3	-0.3226 (0.79)

NOTE: Numbers in parenthesis denote absolute t-ratios. The subscripts denote: 1 = land and buildings; 2 = machinery and equipment; 3 = R&D; 4= labor; and 5 = intermediate inputs.

TABLE 3: Reduced Form Parameter Estimates -- Perfectly Adjustable Factors

Parameter	Estimate	Parameter	Estimate
R_{11}	-0.1362 (0.45)	Q_{23}	0.3310 (0.76)
R_{12}	0.3479 (0.75)	S_{11}	0.1395 (1.83)
R_{21}	0.4364 (2.87)	S_{12}	0.0872 (1.58)
R_{22}	-0.5728 (2.43)	S_{13}	4.3916 (0.95)
Q_{11}	0.1558 (0.34)	S_{21}	0.1188 (3.09)
Q_{12}	-1.2225 (0.27)	S_{22}	0.0772 (2.78)
Q_{13}	0.2409 (0.28)	S_{23}	0.2250 (0.10)
Q_{21}	-0.1964 (0.86	F_1	1527.4000 (16.17)
Q_{22}	0.2508 (0.60)	F_2	380.3700 (7.99)

NOTE: Numbers in parentheses denote absolute t-ratios. The subscripts are defined in Table 2.

TABLE 4: Short- and Long-Run Price and Output Elasticities--Calculated at Sample Means.

	SR	LR		SR	LR
ε_{11}	-0.083 (0.075)	-1.703 (1.530)	ε_{41}	0.049 (0.045)	0.110 (0.101)
ε_{12}	-0.141 (0.133)	-0.214 (0.202)	ε_{42}	-0.075 (0.072)	-0.074 (0.071)
ε_{13}	0.232 (0.220)	0.700 (0.664)	ε_{43}	0.095 (0.093)	0.096 (0.094)
ε_{14}	-0.410 (0.481)	-0.657 (0.770)	ε_{44}	-0.075 (0.092)	-0.180 (0.221)
ε_{15}	0.429 (0.353)	3.010 (2.481)	ε_{45}	0.146 (0.125)	0.130 (0.111)
ε_{21}	0.148 (0.126)	-0.819 (0.695)	ε_{51}	-0.125 (0.058)	-0.165 (0.076)
ε_{22}	-0.244 (0.217)	-0.214 (0.190)	ε_{52}	0.168 (0.082)	0.135 (0.154)
ε_{23}	0.245 (0.221)	0.169 (0.153)	ε_{53}	0.258 (0.116)	-0.050 (0.023)
ε_{24}	-0.699 (0.819)	-0.422 (0.494)	ε_{54}	0.423 (0.274)	0.828 (0.537)
ε_{25}	0.532 (0.401)	2.390 (1.806)	ε_{55}	-0.514 (0.155)	-0.811 (0.246)
ε_{31}	-0.007 (0.004)	-0.851 (0.489)	η_{1Q}	-0.049 (0.311)	1.693 (2.156)
ε_{32}	-0.064 (0.039)	0.150 (0.090)	η_{2Q}	-0.206 (0.704)	1.614 (1.999)
ε_{33}	-0.133 (0.074)	-0.163 (0.091)	η_{3Q}	-0.011 (0.102)	1.287 (1.133)
ε_{34}	0.207 (0.147)	0.511 (0.362)	η_{4Q}	0.140 (0.099)	0.082 (0.041)
ε_{35}	-0.033 (0.013)	1.268 (0.516)	η_{5Q}	0.210 (0.276)	0.218 (0.425)

NOTES: SR and LR denote short- and long-run elasticities. The subscripts are explained in Table 1. In addition: τ = corporate rate and γ = investment tax credit. ε_{ij} denotes the percentage change in input i due to one percent change in the rental rate of input j. η_{iQ} denotes the percentage in input use i due to one percent output change. Numbers in parenthesis denote standard errors.

TABLE 5: Short- and Long-Run Tax Elasticities--Calculated at Sample Means

	SR	LR		
$\xi_{1\tau}$	-0.031	-0.237	$\theta_{1\tau}$	0.100
	(0.028)	(0.201)		(0.110)
$\xi_{2\tau}$	-0.017	-0.142	$\theta_{2\tau}$	0.094
	(0.014)	(0.139)		(0.077)
$\xi_{3\tau}$	-0.006	-0.058	$\psi_{1\gamma}$	-0.044
	(0.005	(0.029)		(0.040)
$\xi_{4\tau}$	-0.002	-0.003	$\psi_{2\gamma}$	-0.041
	(0.003)	(0.003)		(0.037)
$\xi_{5\tau}$	-0.003	-0.011		
	(0.003)	(0.008)		
$\zeta_{1\gamma}$	0.018	0.151		
	(0.018)	(0.147)		
$\zeta_{2\gamma}$	0.007	0.081		
	(0.008)	(0.078)		
$\zeta_{3\gamma}$	0.005	0.054		
	(0.004)	(0.033)		
$\zeta_{4\gamma}$	-0.001	0.002		
	(0.002)	(0.002)		
$\zeta_{5\gamma}$	0.002	0.008		
	(0.002)	(0.005)		

NOTES: SR and LR denote short- and long-run elasticities. The subscripts are explained in Tables 1 and 4. $\xi_{1\tau}$ denotes the percentage change in input use i due to one percent change in τ. $\zeta_{1\gamma}$ denotes the percentage change in input use i due to one percent change in γ. $\theta_{i\tau}$ denotes the percentage change in the rental rate of input i due to one percent change in τ. $\psi_{1\gamma}$ denotes the percentage change in rental the rate of input i due to one percent change in γ. Since γ was introduced in 1976-77, the respective elasticity is the average of 9 observations only.

factor utilization in both areas whereas increases in investment tax credit have the opposite effects. These effects as indicated by elasticity values are uniformly small.

VI. The Impact of Tax Policies On Investment in Physical and Knowledge Capital

The estimated model can be used to evaluate the investment impact of alternate tax policy instruments per dollar of foregone revenues and using this criterion to rank instruments in terms of their relative efficacy. For this purpose, model parameters were used to simulate the impact of three policy changes. First policy simulation assumes an increase in investment tax credit from 15% to 30% and estimates the impact on factor demands for such a change for three most recent years (see Table 6). A doubling of investment tax credit expectedly leads to uneven changes in demand for various sectors with the machinery and equipment receiving the most stimulus and R&D investment the least augmentation. While this policy change results in a major increase in aggregate investment, foregone revenues exceed the investment stimulus by a small margin. Incremental benefit-cost ratio is estimated to equal 0.95 with such a policy initiative.

Pakistan offers full expensing option for R&D investment. This measure according to the calculations presented in Table 7 is seen to be a cost-effective instrument for R&D investment stimulation. Incremental benefit-cost ratio is estimated to be greater than one (1.49).

A third simulation assumes a corporate tax rate reduction from 55% to 30%. Such a tax reduction is estimated to have the greatest positive impact in the short run for machinery and equipment and least for structures (see Table 8). Foregons revenues associated with such a change are estimated to exceed changes in aggregate investment by a significant margin. The incremental benefit-cost ratio is calculated to be less than one (0.71).

VII. Policy Implications

This paper examined the tax sensitivity of investment in physical and R&D capital in Pakistan and found that while such investment was sensitive to various tax measures, the elasticity values were without exception quite small. Further, incremental benefit-cost ratio associated with changes in investment tax credit and corporate tax rate was smaller than one. Full expensing option for R&D investment was found to be cost effective. Pakistan currently follows a high tax and low incentives regime in major metropolitan areas and a high tax and high incentives regime in selected less developed areas. The analyses presented in this paper suggests that fiscal incentives for investment were generally not cost effective and therefore public policy emphasis should be on creating a stable low tax regime.[5] In terms of short run investment stimulation, investment tax credit was found to be more efficient than the corporate tax rate reductions.

TABLE 6: Short-Run Effects of a Major Increase in Physical Investment Tax Credit*

	Percent	Cumulative 1983-85 (Million Rupees)
Effects at Existing Output Levels		
A. On Factor Demands:		
Structures	8.8	4,484
Machinery and Equipment	15.7	25,201
R&D	4.9	241
B. Total Change in Investment		29,926
C. Foregone Revenues		31,416
D. Incremental Benefit-Cost Ratio (B ÷ C)	0.95	

NOTE: * Model calculations by assuming an increase in investment tax from 15% to 30%.

TABLE 7: Implications of Full Expensing Option for R&D Investment and Government Revenues

		1983-85 (cumulative thousands rupees)
A.	R&D Investment Gains	443,130
B.	Loss in Government Revenues	298,041
	Benefit-Cost Ratio (A + B)	1.49

Table 8: Short-Run Effects of a Major Reduction in Corporate Income Tax Rate*

	Effects at Existing Output Levels	
	Percent	Cumulative 1983-85 (Million Rupees)
A. On Factor Demands		
Structures	3.24	1,763
Machinery and Equipment	13.66	21,671
R&D	3.96	192
B. Total Changes in Investment		23,832
C. Foregone Revenues		33,511
D. Incremental Benefit-Cost Ratio (B ÷ C)	0.71	

NOTE: * These calculations are based on model simulations assuming corporate tax rate reduction from 55% to 30%.

ENDNOTES

1. Recent advances in dynamic duality (see Epstein (1981); Epstein and Denny (1983)) have facilitated empirical applications of such models, so that the structure of the industry can be examined without imposing severe restrictions on the technology.

2. A complete characterization of the properties of the value function as well as the cost function can be found in Epstein and Denny (1983), while the profit function can be found in Epstein (1981)).

3. Because of the nonlinear nature of the model and the large number of parameters to be estimated, some simplifications were made. First, the model was estimated in reduced form. We estimated expressions (A11) and A12) as described in Appendix A. Second, the two blocks of equations were estimated separately, i.e., we first estimated the three equations corresponding to the quasi-fixed factors and then the ones corresponding to the perfectly adjustable factors. Finally, in order to account for heteroskedasticity, we divided the stocks by the output, so the system was expressed in input/output ratio form.

4. The results reported here are based on static expectations. In addition we run the model by using first and second order autoregressive expectation schemes regarding rental rates and output. Results regarding land and buildings and machinery and equipment were fairly insensitive in terms of adjustment rates and elasticities. On the contrary R&D showed a high degree of sensitivity.

5. A referee has argued that this conclusion does not strictly follow from the model results.

REFERENCES

Auerbach, A. "The Cost of Capital and Investment in Developing Countries,"Working Papers Series 410, Public Economics Division, The World Bank, April 1990.

Berndt, E. and C. Morrison. "Short Run Labour Productivity in a DynamicModel." *Journal of Econometrics*. 16(1981):339-365.

Bernstein J.I. *Research and Development, Tax Incentives, and the Structure of Production and Financing*. University of Toronto Press, Toronto, 1986.

Eisner, R. and I. Nadiri. "Investment Behavior in Neoclassical Theory." *Review of Economics and Statistics*. 50(1968):369-382.

Epstein, L.G. and M.G.S. Denny. "The Multivariate Flexible Accelerator Model:Its Empirical Restrictions and an Application to U.S. Manufacturing." *Econometrica*. 51(1983):647-674.

Epstein, L.G. and A.J. Yatchew. "The Empirical Determination of Technology and Expectations: A Simplified Procedure." *Journal of Econometrics*. 27(1985):235-258.

Epstein, L.G. "Duality Theory and Functional Forms for Dynamic Factor Demands." *Review of Economic Studies*. 48(1981):81-95.

Government of Pakistan. Federal Bureau of Statistics. *Census of Manufacturing Industries*, Various Issues. Karachi.

Government of Pakistan. Finance Division. *Economic Survey Statistical Supplement: 1987-88*. Islamabad.

Lucas, R. "Optimal Investment Policy and the Flexible Accelerator." *International Economic Review*. 8(1967):78-85.

Meese, R. "Dynamic Factor Demand Schedules for Labor and Capital Under Rational Expectations." *Journal of Econometrics*. 14(1980):141-158.

Mohnen, P.A., M.I. Nadiri, and I.R. Prucha. "R&D, Production Structure and Rates of Return in the U.S., Japanese and German Manufacturing Sectors: A Non-separable Dynamic Factor Demand Model." *European Economic Review*. 30(1986):749-771.

Mortensen, D.T. "Generalized Costs of Adjustment and Dynamic Factor Demand Theory." *Econometrica*. *41(1973):657-665*.

McLaren, K. and R. Cooper. *"Intertemporal Duality: Application to the Theory of the Firm."* *Econometrica*. 48(1980):1755-1762.

Nadiri, M.I. and I.R. Prucha. "Comparison and Analysis of Productivity Growth and R&D Investment in the Electrical Machinery Industries of the United States and Japan." Mimeo, New York University and University of Maryland, January 1989.

Nadiri, I. and S. Rosen. "Interrelated Factor Demand Functions." *American Economic Review*. 59(1969):457-471.

Shah, Anwar (1986). Research and Development Investment, Industrial Structure, Economic Performance and Tax Policies. *Finance Canada*. Discussion Paper, Ottawa, November.

Treadway, A.B. "Adjustment Costs and Variable Inputs in the Theory of Competitive Firm." *Journal of Economic Theory*. 2(1970):329-347.

Treadway, A.B. "The Globally Optimal Flexible Accelerator." *Journal of Economic Theory*. 7(1974):17-39.

APPENDIX A: DERIVATION OF INPUT DEMANDS

Rewrite the value function defined in (6) as:

$$\text{(A1)} \quad V(K,Y,P) = (1/2)(P'B_{pp}P + W'B'_{pw}P + P'B_{pw}W + W'B_{ww}W)Y + P'A_{pk}^{-1}K + W'A_{wk}K + P'r^{-1}A_{pk}^{-1}H_p + W'r^{-1}F_p.$$

and consider again the Shephard's lemma analogue regarding the quasi-fixed inputs,

$$\text{(A2)} \quad \dot{K}^*(K,Y,P) = V_{pk}^{-1}(rV'_p - K)$$

Differentiating (A1) with respect to P and transposing the resulting expression gives:

$$\text{(A3)} \quad V'_p = (B_{pp}P + B_{wp}W)Y + A_{pk}^{-1}K + r^{-1}A_{pk}^{-1}H_p.$$

Differentiating V'_p with respect to K and inverting yields:

$$\text{(A4)} \quad V_{pk}^{-1} = A_{pk}.$$

Substituting (A3) and (A4) into (A2) results in:

$$\text{(A5)} \quad \dot{K}^*(K,Y,P) = A_{pk}(r((B_{pp}P + B_{wp}W)Y + A_{pk}^{-1}K + r^{-1}A_{pk}^{-1}H_p) - K).$$

Rearranging terms in (A5) yields the dynamic factor demands:

$$\text{(A6)} \quad \dot{K}^*(K,Y,P) = (r - A_{pk})K + rA_{pk}(B_{pp}P + B_{wp}W)Y + H_p.$$

The Shephard's lemma analogue regarding the perfectly adjustable inputs is given by:

$$\text{(A7)} \quad Z^*(K,Y,P) = -rV'_w + V_{wk}\dot{K}^*.$$

Differentiating (A1) with respect to W and transposing the resulting expression gives:

$$\text{(A8)} \quad V'_w = (B_{ww}W + B_{pw}P)Y + P'A_{pk}^{-1}K + A_{wk}K + r^{-1}F_p.$$

Differentiating J_w with respect to K yields

$$\text{(A9)} \quad V_{wk} = A_{wk}.$$

substituting (A8) and (A9) into (A7) and rearranging terms results in the input demands for the perfectly adjustable inputs:

$$\text{(A10)} \qquad Z^*(K,Y,P) = -r(B_{ww}W + B_{pw}P)Y - rA_{wk}(K - r^{-1}\dot{K}^*) - F_p.$$

To avoid nonlinearities in the estimation, we expressed (A6) and (A10) in reduced forms as:

$$\text{(A11)} \qquad (\dot{K}^*,Y,P) = MK + (EP + GW)Y + H_p \text{ and}$$

$$\text{(A12)} \qquad Z^*(K,Y,P) = (RW + QP)Y + S(K - r^{-1}\dot{K}^*) - F_p.$$

where $M = (r - A_{pk})$, $E = rA_{pk}B_{pp}$, $G = rA_{pk}B_{pw}$, $Q = -rB_{ww}$, $R = -rB_{ww}$, and $S = -rA_{wk}$.

A descriptive exposition of the reduced form matrix parameters has as follows:

$$M = \begin{bmatrix} M_{11} & M_{12} & M_{13} \\ M_{21} & M_{22} & M_{23} \\ M_{31} & M_{32} & M_{33} \end{bmatrix}, \; E = \begin{bmatrix} E_{11} & E_{12} & E_{13} \\ E_{21} & E_{22} & E_{23} \\ E_{31} & E_{32} & E_{33} \end{bmatrix}, \; G = \begin{bmatrix} G_{11} & G_{12} \\ G_{21} & G_{22} \\ G_{31} & G_{32} \end{bmatrix}, \; H_p = \begin{bmatrix} H_1 \\ H_2 \\ H_3 \end{bmatrix},$$

$$R = \begin{bmatrix} R_{11} & R_{12} \\ R_{21} & R_{22} \end{bmatrix}, \; Q = \begin{bmatrix} Q_{11} & Q_{12} & Q_{13} \\ Q_{21} & Q_{22} & Q_{23} \end{bmatrix}, \; S = \begin{bmatrix} S_{11} & S_{12} & S_{13} \\ S_{21} & S_{22} & S_{23} \end{bmatrix}, \; F_p = \begin{bmatrix} F_1 \\ F_2 \end{bmatrix}.$$

The structural form parameters of (A11) and (A12) are then recovered from the reduced form as: $A_{pk} = (r - M)$, $B_{pp} = (r - M)^{-1}r^{-1}E$, $B_{pw} = (r - M)^{-1}r^{-1}G$, $B_{ww} = -r^{-1}Q$, $B_{pw} = -r^{-1}R$, and $A_{wk} = -r^{-1}S$ where M, E, G, Q, R, and S are the estimated reduced form matrix parameters.

APPENDIX B: DATA DESCRIPTION AND CONSTRUCTION OF VARIABLES

Most of the data used in this study were obtained from various issues of *Census of Manufacturing Industries* and the *Economic Survey Statistical Supplement: 1987-88* and cover 1956-1985 period. The construction of variables was done as follows:

Land and Buildings: Quantity of land and buildings was constructed by dividing stocks by the investment deflator. Stocks were constructed by employing the perpetual inventory method, with depreciation rate set equal to 0.05. As a starting value of stocks we used the 1956 end-of-year book value of land and buildings. The rental rate of land and buildings was calculated by invoking the following formula (see Auerbach, 1990): $p_t = q_t(r+\delta)(1-\gamma-\tau z)((1-\tau)\Theta)^{-1}$, where: p_t = user cost (rental rate) of land and buildings; q_t - investment deflator; r = weighted average of the real costs of debt and equity finance where the weight is given by the shareholders' equity to total capital employed ratio (constructed from data reported in various published and unpublished sources; ranging between 0.047 and 0.110; δ = depreciation rate (set to 0.05); γ =investment tax credit (introduced in 1977, 0.15); τ = corporate tax rate including super tax rate (equal to 0.55 as reported in budget speeches); z = present value of investment allowances received by the firm; Θ = profitability parameter (set to 0.90).

Machinery and Equipment: Quantity and rental rate of machinery and equipment were constructed analogously to that of land and buildings variables except that the depreciation rate used is 0.10.

R&D: Quantity of R&D was constructed by dividing R&D stocks by the price of R&D. R&D stocks were constructed using the perpetual inventory method with the depreciation rate set equal to 0.10. R&D expenses were obtained from *United Nations* (Industrial Statistics Yearbook) and various Government of Pakistan data sources. When data on R&D investment was not available we used the royalties and other fees expenses. Rental rate of R&D was calculated invoking the formula for rental rate described earlier and setting z = 1.0 and δ = 0.10.

Labor: Quantity of labor was measured as the total number of days worked during the year. The price index was constructed by dividing total employment cost during the year by number of days worked.

Intermediate Inputs: Intermediate inputs include electricity, petroleum fuel, natural gas, and imported and domestically produced miscellaneous materials. Aggregate price and quantity indices were constructed from these components by using the Tornquist approximation of Divisia index.

Output: Quantity of output was constructed by dividing total value of output by the manufacturing output deflator.

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